REMARKS

This paper is in response to the final Office Action mailed January 23, 2006. By this paper, claims 12 and 15 are amended and claims 17-20 are added. Therefore, claims 1-20 are pending upon entry of this paper.

Response to Rejection of Claim 1

Claim 1 is directed to a physical vapor deposition (PVD) method for deposition of dielectric materials, including low dielectric constant (low-k) materials, onto substrates during the fabrication of integrated circuits and other electronic, opto-electronic, microwave, and micro electro-mechanical (MEM) devices. More particularly, claim 1, is directed to a method for the physical vapor deposition of dielectric material onto a substrate comprising, *inter alia*:

> forming an energized monochromatic ion beam;
> converting said ion beam into an energized monochromatic beam of neutrals;
> directing said beam of neutrals toward a sputtering target;
> exposing said target to bombardment by said beam of neutrals;
> sputtering particles from said target;
> forming a cloud of said sputtered particles proximate to a substrate; and
> depositing said sputtered particles onto said substrate

Claim 1 in the application stands rejected as being anticipated by the non-patented literature Albertinetti et al. Applicant respectfully traverses this rejection. Claim 1 is novel and patentable over the references of record, and particularly over Albertinetti et al., because the cited art does not show or suggest a method for the physical vapor deposition of dielectric material onto a substrate comprising converting an ion beam into an energized monochromatic beam of neutrals as required by claim 1.

Albertinetti et al. discloses a method of forming dielectric $SiO2$ and $TiO2$ films on a substrate using PVD. As recognized by the Examiner, a Kaufman-type ion gun with grid optics was used. The ion beam space charge is neutralized by electrons from a plasma bridge neutralizer (PBN) or

hollow cathode neutralizer (HCN). Albertinetti et al. states that "[t]he PBN was mounted on the face of the ion gun" (which is to some degree similar to teaching of the previously discussed Katsube et al. apparatus) while "[t]he HCN was mounted on the wall of the chamber, and it pointed towards beam axis". Albertinetti et al., page 5621. It was also stated that "[t]he HCN was positioned in the way to neutralize both the sputter beam and the beam from the ion assist gun". Albertinetti et al., page 5621 (emphasis added). Although, the information about the HCN mount is very limited and sketchy, it is still clear that the neutralizing electron beam from the HCN did not coincide with the ion beam axis (path), but instead the neutralizing electron beam from HCN crossed the ion beam at some (unspecified) angle. This approach of mounting HCN is believed to be very typical since electrons from HCN will have trajectories which would never be intercepted by either the target or the substrate. This reduces the amount of heat the target or growing film on the substrate is exposed to.

However, Applicant disagrees with the Examiner's opinion that ion beam is converted into a beam of neutrals by the PBN or HCN as neutralizing a beam as described in the Albertinetti et al. reference is not the same as converting the beam to a beam of neutrals as required by claim 1. It is well known that the primary function of neutralizers with Kaufman-type sources is to compensate the space charge of ion beam to prevent beam divergence due to the low ion energy (50 – 2000 V) and high current density (0-350 mA). (The voltage/current data for a Kaufman-type ion gun manufactured by Ion Tech Inc. with an 11 cm DC ion source (as used in the Albertinetti et al. reference) was obtained from the Veeco Instruments Web site). It is known that passing an ion beam through a vacuum chamber (chamber pressure of 0.5 - 1.0x 10^{-4} Torr as taught in Albertinetti et al. can be considered a relatively good technical vacuum) when the beam has high current density and low ion energy (low accelerating voltage), that the beam will spread out due to the repulsing effect of positive charge of ions forming the beam. This repulsion causes the beam cross-sectional diameter to increase. Typically, to compensate for this positive space charge, a beam of electrons is injected into this positive space charge of ions. The electron beam neutralizes the positive space charge of ions by adding an "equal" amount of negative space charge produced by the electrons. In this case, the both beams "coexist" together with relatively low near-field intercalation (mutual recombination) but they have very effective far-field interaction based on Coulomb Law, which glues

opposite charges together still maintaining them at some physical distance one from another. The result is the space charge of the ion beam is neutralized so that the ion beam does not spread any more. However, the individual ions maintain their original charge energy and momentum.

The present invention uses a very different approach of converting the ion beam into an energized monochromatic beam of neutrals. The principal difference is in utilization of a charge-transfer chamber to convert gradually fast ions into neutral atoms along the path of beam propagation. As shown in Fig.1 of the application, the monochromatic ion beam, which has a nearly zero fast atom component in the vicinity of the either side of ion optics aperture 2, propagates along charge-transfer chamber 3, which is filled with a gas, such as rarified Ar gas. The pressure of rarified gas inside chamber 3 is not equal to the near vacuum taught in the Albertinetti apparatus. Instead, the pressure inside of chamber provides a charge-transfer collision process between fast Ar^+ and low energy Ar^0 atoms. As set forth in the specification, an ion energy in the range of 100-400 eV provides a preferable cross-section for charge transfer collision process between Ar^+ and Ar^0. Nowhere does Albertinetti et al. teach or suggest converting the ion beam into a beam of neutrals.

Applicant submits that the remaining references cited by the Examiner, including Katsube et al, Saito et al., Harper et al., Mattox, also do not teach converting the beam into a beam of neutrals, and therefore cannot cure the deficiencies of Albertinetti et al.

Accordingly, claim 1 is not anticipated by or made obvious by the cited reference and favorable consideration of claim 1 is respectfully requested. Claims 6 and 15 contain limitations similar to the one described above. Therefore, these claims are patentable for at least the same reasons. Claims 2-5, 7-14 and 16, depending directly or indirectly from one of claim 1, 6 or 15 are submitted as patentable over the cited references for at least the same reasons.

Claims 12 and 15 have been amended to recite that the step converting the ion beam into an energized monochromatic beam of neutrals is performed by directing the ion beam through a charge transfer chamber containing a volume of relatively slower moving neutrally charged Ar gas. It is believed that this limitation further distinguishes these claims over the cited art.

New Claims

Dependent claims 17-20 have been added to further distinguish the cited prior art. With

respect to claims 18-20, as described in paragraph [0022] of the specification, this new PVD method provides a significant improvement because directing a converted beam of neutrals toward the sputtering target eliminates the need to require target surface charge compensation. Conventional PVD systems require target surface charge compensation in order to provide continuous sputtering of dielectric materials as is well known in the art. Such target surface charge compensation is typically performed by electrons that have been extracted from the plasma of RF discharge, or provided by an external source. As such, the additional electron bombardment of the target surface significantly raises the target surface temperature and may result in thermal or thermo chemical destruction of the target material. For this reason, organic based materials could not be sputtered by conventional RF sputtering.

Conclusion

In view of the remarks made herein, Applicant submits that the claims presented herein are patentably distinguishable from the art applied and prompt allowance of the application is respectfully requested.

Should the Examiner determine that anything else is desirable to place this application in even better form for allowance, the Examiner is respectfully requested to contact the undersigned by telephone.

Respectfully submitted,
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